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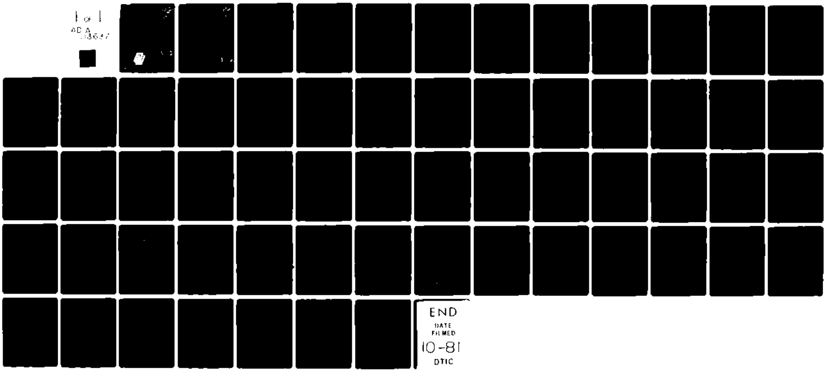

DECISION PROCESSES LABORATORY
UNIVERSITY OF OKLAHOMA

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LEVEL II

AN EVALUATION OF HUMAN ACT GENERATION PERFORMANCE

CHARLES F. GETTYS, CAROL MANNING, AND JEFF T. CASEY

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DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF OKLAHOMA
NORMAN, OK. 73019

Abstract:

A series of experiments addressed the adequacy of act generation performance, an important precursor to problem structuring. Each of two decision problems was studied by a series of three experiments. In the first experiment, subjects were given a realistic decision problem and asked to respond with any act occurring to them. In the second experiment, the acts suggested were evaluated by different subjects for feasibility. In a third experiment, additional subjects estimated the utility of the acts judged feasible. The act generation performance of subjects was evaluated using two techniques. First, a decision tree was generated by the experimenters by combining the acts suggested by all subjects. The decision tree generated by each subject was compared with the experimenter-generated tree. It was found that subjects failed to generate important limbs and branches of the group decision tree. Second, the quality of the trees generated by individual subjects was evaluated by an opportunity loss calculation. This calculation provided an estimate of the potential cost of failing to generate limbs and branches of the decision tree. The opportunity loss analysis suggested that the failure to generate a complete tree could be costly.

An Evaluation of Human Act Generation Performance

Several specific processes occur prior to making a carefully-considered decision. First, a decision maker must recognize that a problem exists for which a decision is required. Next, relevant components or dimensions of the problem are identified. These components include 1) acts which may potentially lead to the goal, 2) states of the world (hypotheses) which may influence the outcomes of these acts, and 3) possible consequences or outcomes of acts. These processes, and others, are included in the general term "predecision processes." Predecision processes are important precursors to the actual decision, and can have a major impact on the quality of the decision (Humphreys, 1979).

In this paper we concentrate on one of the predecison processes, act generation. Act generation is the process of generating options for action available to the decision maker. These acts, designed to achieve the desired goal, are the "menu" of options from which the decision maker must eventually choose. It is quite important that this menu be as complete as possible, to offer the decision maker an effective course of action. If the list of acts generated by the decision maker is incomplete, the subsequent decision may not be the best which could be made under the circumstances, leading to possible "opportunity loss."

The investigation of human act generation capablilites has received scant attention to date. The lack of concern with act generation, and predecision processes in general, is probably due to several historical factors. These topics initially appeared to be intractable for several reasons. First, early research on human decision making compared human performance with optimal models. As there were no optimal models for predecision processes, the topic was largely ignored. Raiffa (1968), for example, stated that elicitation of structure was an important problem he "wanted to duck." The recent emergence of a cognitive approach to decision making (Wallsten, 1980) has broadened the areas of inquiry to include <u>all</u> aspects of decision making, not just tractable candidates for normative modeling. Second, even though predecision processes are legitimate candidates for study from a cognitive perspective, the processes themselves appeared to be intractable topics of study which would not reveal their secrets easily.

There has been some research on hypothesis generation, which is a process relevant to act generation (Gettys and Fisher, 1979; Manning, Gettys, Nicewander, Fisher, & Mehle, 1980; Mehle, Gettys, Manning, Baca & Fisher, in press). The major conclusion of these and other studies was that hypothesis generation performance is largely dependent on the success of accessing information available in memory. Subjects failed to retrieve many important hypotheses from memory, yet when asked to assess the completeness of their retrieval, they grossly over-estimated it (Mehle, et. al., in press). This series of studies suggests similar deficiencies in accessing acts stored in memory will be found, due to the similarity of act and hypothesis generation.

Pitz, Sachs and Heerboth (1980) investigated methods of eliciting acts from subjects in the first study on the topic of act generation in a decision theory context. They found serial presentation of problem objectives or goals enhanced act generation performance as compared to conditions where subjects were given either exemplar acts or all problem objectives simultaneously. They also observed that subjects did not seem to generate a very complete set of acts, averaging less than a third of the acts the experimenters thought were "worth considering." However, subjects had limited time to respond, and their performance might have been better had they been allowed unlimited time.

Decision problem structuring is the process of explicitly modeling a decision problem for purposes of Decision Analysis. It is curious that considerable effort has been devoted to enhancing act generation performance (and other predecision processes) given the paucity of information on the quality of unaided human problem structuring. Nevertheless, such efforts exist (e.g. Leal and Pearl, 1977; Pearl, Leal & Saleh, note 1; Weiss & Kelly, note 2; Merkhofer, Miller, Robinson & Korsan, note 3). The work of Pearl and his colleagues is of particular interest because they speculated on the cognitive mechanisms involved in act generation.

Given the near absence of research on human act generation and the considerable interest in improving act generation, it would seem desirable to investigate human act generation capabilities. The present study attempts provide a preliminary examination of act generation, one that will establish the basis for a study of the cognitive processes involved. Two major questions will be addressed:

1. <u>To what extent can subjects generate a complete set of acts?</u>

2. <u>What is the potential cost of any failures to generate important acts?</u>

The first of these questions is important because the Pitz, et. al. study addressed the question of capability only incidentally to its main purpose—comparing various act elicitation techniques. They used no criterion of performance, and allowed only a limited amount of time for each problem. Thus, their data are less than definitive. More basic information on act generation performance is needed. Can subjects generate most of the important acts to solve a problem, or is their unaided performance so deficient that even more attention should be given to aiding act generation for important decisions?

The importance of the second question becomes clear when it is realized that it is unnecessary (except perhaps from a Utopian, normative view) for the decision maker to generate <u>all</u> important acts. It is necessary for at least one satisfactory act to be generated, and it may be sufficient if only a few very attractive acts are on the "menu". After fulfilling the above requirements, the practical importance of failing to generate all acts may be small. Practical decision makers may "satisfice", choosing the first act meeting some minimum criterion of acceptability (Simon, 1956). Even if they "optimize" by generating a number of acts then picking the best, the difference between their best act and the theoretically optimum act may be small. Therefore, a second interesting question regarding act generation performance is the cost of failing to generate the optimum act, or the "opportunity loss" (Raiffa, 1968) due to deficiencies in act generation. Even though subjects fail to generate the "optimal" act, they may generate another act having a similar utility. In this case, failure to generate a complete menu of acts would be of little importance. If, however, the difference in utility between the best act generated and the optimal act is large, then there would be cause for concern.

Question 1 is addressed by an experiment in which subjects were given a realistic decision problem and were asked to generate any act that might conceivably solve the problem. The second question is addressed in a second section of the paper by a series of two experiments. In the first experiment of the series, acts generated by previous subjects were screened for feasibility. The final experiment obtained utility estimates for the feasible acts. These estimates permitted calculation of "opportunity loss".

A criterion for act generation performance

The seemingly intractable problem in a study of act generation capability is the difficulty in creating a criterion of performance. Two major approaches can be used to create such a criterion. First, one can refer to authoritative sources (Fischhoff, Slovic, and Lichtenstein, 1978) such as an "expert's" structure of the act generation problem. While this may be an excellent approach when it can be utilized, no such authoritative sources exist for most interesting decision problems.

A second approach does not rely on expert judgment, but instead uses ordinary subjects' responses. In this procedure, described in more detail in Gettys, Mehle, Baca, Fisher, and Manning (note 4), the responses of a group of subjects are pooled to create a lower-bound estimate of the number of possible acts. A group menu of acts which might successfully solve the problem is created by taking the union of the acts suggested by each individual. The result is a lower-bound estimate in that a few more potential acts would be discovered if more subjects were added to the group. This approach has the advantages that it can be applied to a wide variety of situations, and it is a conservative criterion of performance because it is a lower-bound estimate. Its major disadvantage is that it is necessary to add many subjects before the pool of acts ceases to grow.

Experiment 1

Method

Criteria for selecting problems. In choosing act generation problems we were concerned with the issue of the possible interaction between expertise and the performance of the subjects. Ideally, expert populations might be preferred over college student populations, but the pooling and other procedures employed required large numbers of subjects. We used over 500 subjects in these experiments and related projects, and would have found it difficult to find even 50 expert subjects. Our strategy was to attempt to find meaningful decision problems for our subjects— problems for which they were suitably "expert" so our results could be generalized to other populations. Related work on hypothesis generation has suggested expert subjects and college students have similar deficiences in accessing information in memory (Gettys, et. al., note 4; Mehle, note 5).

The problems were chosen with the following criteria in mind:

1. The problems should be ones with which the subjects are knowledgable.

2. The problems should be "open-ended" in that possible acts should not be easily enumerable, or generated by any mechanical rule.

3. The problems should be tractable in the sense that the number of acts generated by the subjects should not be so large as to be unmanagable.

4. The problems should resemble problems encountered in everyday life, rather than being highly artificial problems such as those used by some researchers in problem solving, (e.g. "Missionaries and Cannibals" or "Towers of Hanoi").

Problems. Two act generation problems were used in this investigation. After completing data collection for the first problem, we decided the results were of sufficient interest to warrant including a second problem as a check on the generality of the results of the first problem. The two problems used were well-suited to our subject population. The first problem, called "Parking", asked the subjects to assume they were members of a hypothetical student committee appointed by the officials of the University to provide student input on the University's parking problem. Like most major universities, the University of Oklahoma has a perennial parking problem. This problem is discussed frequently in the student newspaper. Most students engage in frequent, if not daily, hunts for a parking space. The subjects' task was to list all acts which could be taken by the University to reduce the severity of the parking problem. The text of the parking problem is given below.

PARKING

> It is difficult to find a place to park at OU. Although approximately 21,000 students are enrolled and about 3500 faculty and staff are employed, about half that many parking spaces are available.
>
> There are 6850 parking places available on campus for faculty/staff, commuters, housing, Law, and OCCE. The Lloyd Noble Center provides an additional 3500 spaces, yielding a total of 10,350. One space for every two people doesn't sound too bad, but anyone who has tried to find a parking space at 9:00 a.m. knows this is a real problem.
>
> Suppose you are a member of a student organization which is researching this problem for officials of the University. Your task is to suggest as many possible solutions to the committee as you can. These solutions need not be "perfect"; often good solutions are derived from ideas which at first seem silly. The University officials will worry about how to pay for any solutions suggested and how to convince the involved parties to accept the decision. Your task is simply to think of all possible solutions which might be effective.
>
> It is important for you to enter all options which occur to you. This is similar to "thinking out loud." We do not want you to censor your options and only enter the ones which you think are particularly good. Put down all options which occur to you, good or bad. Your score in this experiment is determined by the number of options you generate, not how good they are.

The second problem involved finding a place to live for an impecunious Canadian friend who arrived on campus in such a state of financial disarray that he lacked sufficient funds to pay for a dormitory room or an apartment. The text of the problem was carefully worded so conventional solutions, such as getting a job or asking his parents for more money, were not viable options. This problem is called the "Living" problem, and its complete text is found in Appendix A.

Subjects. Subjects were 60 introductory psychology students from the University of Oklahoma who participated in the experiment for course credit. Thirty subjects generated acts for the Parking problem and 30 subjects generated acts for the Living problem. Subjects were recruited who knew how to type, and had to demonstrate they could type at least 20 words per minute to participate in the experiment.

Instructions. The instructions were presented by a computer. Several major topics were covered in the instructions. After the subject was told the purpose of the experiment in general terms, the importance of responding with all possible acts was emphasized in several different paragraphs. Subjects were instructed: "... We are interested in how many alternate solutions you can dream up. It is not important that these solutions be the best solutions to the problem; we are interested in even remotely possible solutions that occur to you." In another section of the instructions a paragraph was devoted to exhaustively searching memory: "...Don't give up on a problem until you are sure you have run out of possible solutions. One way to avoid giving up too soon is to continue to search your memory for a while even though you believe you have thought of everything. Usually, a number of other possibilities will occur to you..." This advice was reiterated in condensed form when the subjects indicated they had completed the problem.

Other parts of the instructions were devoted to interacting with the computer's menu to 1) Review the instructions of the experiment, 2) Display the problem on the screen again, 3) Enter a new act, 4) Review acts already generated (to avoid duplication), 5) Get help on any aspect of the menu, and 6) Terminate the experiment.

After the subjects had read these instructions, they were given a practice problem. The experimenter helped them during the practice problem and did not let the subject move on to the main problem until it was clear the subject understood the experiment. The practice problem consisted of generating acts which might be taken if one ran out of gas on the freeway and had no money.

After completing the practice problem, subjects were shown exemplar acts generated by a highly creative subject for the same problem. This was done to encourage them to think of as many acts as possible.

Subjects were told there was only one problem after the practice problem, and they were to do the best job they possibly could on the single problem. They were also told they could take as much time as they needed to complete the main problem. These instructions were developed on the basis of several pilot studies, in which it was found working on a single problem leads to a considerable increase in the number of responses generated.

Procedure. The subjects interacted with the computer by reading the textual material from a CRT display and entering their acts via the keyboard. The previously-described menu of commands was used by subjects to control the computer. For example, subjects generated acts by first, hitting the "E" key which signified they wanted to "Enter" an act, then typing their act. Subjects were then asked to type a short justification for the act. This was done to aid the experimenters in interpreting subjects' reasoning behind suggesting some of the acts. After the justification was entered, the computer returned to the menu. When subjects chose to end the problem, they were asked to think again of any acts which might successfully solve the problem.

Subjects then generated as many acts as they could for either the Parking or the Living problem. The experimenter was present for the entire session and answered questions at any time.

Results and Discussion

Creating the act pool by combining equivalent acts. Subjects generated a total of 335 acts for the Parking problem and 362 acts for the Living problem. Many acts were equivalent or highly similar, although the words used to describe the acts differed. To combine equivalent acts, three experimenters served as judges to independently group acts which they felt were equivalent. For example, a suggestion to build a six-story parking garage was considered to be equivalent to building a ten-story garage. The equivalence judgments were then analyzed by a computer program. Acts which were classified as equivalent by all three independent judges were combined into one act. This procedure resulted in an act pool of 128 "unique" acts for the Parking problem and 155 "unique" acts for the Living problem.

A hierarchical organization of the acts. It is not reasonable to expect a subject to generate as many acts as the pooled responses of 30 subjects. A more realistic expectation is that a good act generator should be able to retrieve examples of the major types of acts from memory. Performance can be evaluated by examining the responses of an individual with respect to some hierarchical structure created by logical analysis of the ideas embodied in the unique acts. When the unique acts were inspected it was clear they could be organized into a hierarchical structure. Certain generic ideas were shared by many of the acts, and there were major variations of these ideas, as well as minor variations. Because the hierarchical structure is tree-like, we named the generic ideas "limbs", major variations "branches", and minor variations "twigs". By comparing the act tree generated by each subject with the "group" tree created by pooling the responses of all 30 subjects, we can identify an individual's omission of important limbs and branches.

Two experimenters structured the unique acts generated for the Parking and Living problems. The results are shown in Appendices B and C, respectively. The limbs, branches, and twigs in the trees are denoted by a decimal notation. For example, the notation 2.3.1 for the Parking problem refers to a proposal to build a below-ground parking stucture. This act is a member of generic limb 2, "Increase available space for parking", and is found on branch 3, "Build parking structures", a branch it shares with another act, "A high-rise parking structure" (2.3.2). Most limbs contained many branches, and some branches had a large number of twigs. Each twig represents at least one act, although some twigs combine several acts. The trees were created with a much more liberal definition of equivalence than used in the "three judge" procedure to keep the size of the tree within manageable proportions. Less specific acts were associated with a branch or even a major limb, rather than a twig.

An inspection of Appendices B and C reveals the incredible richness of the Parking and Living trees created from the pooled acts. This is even more remarkable when it is considered the trees provide lower-bound estimates of the "hypothetical", asymptotic trees created by including many more subjects in the pooling process. The Parking problem has seven major limbs, and the Living problem has nine. Examples of major limbs in the Parking problem include "Use available parking space more efficiently", "Increase available space for parking", "Reduce demand for parking", and "Change parking priorities". Other limbs, such as "Provide faculty and Staff with housing within walking distance" and "Frivolous and other responses", while consisting mostly of acts that are patently unrealistic, are included because of their intrinsic interest. These limbs contain material suggestive of some strategies subjects use during act retrieval. Limb 7, "Responses that combine two or more options from above", is based on the response of one subject and may have resulted from a misunderstanding on the part of that subject. The instructions specified that the task was to create a menu of possible acts, and we did not specify that only one act would be picked from that menu. However, it is interesting to note only one subject specified the possibility of combining acts.

The tree created for the Living problem is similar to the Parking problem tree in many ways. Examples of major limbs included in the tree for the Living problem are "Live somewhere without paying rent", "Exchange goods or services for money or place to live", "Obtain money through other sources", "Ask someone for help", "Try to change regulations", "Change current plans", and "Prepare in advance". Subjects often suggested acts involving changing regulations or violating the constraints placed on the problem by the experimenter. Again, subjects suggested acts having a small probability of successfully solving the problem. Those acts were included in two categories, "Long shots", and "Acts which will not solve problem".

Constructing a tree with cluster analysis. It could be argued that the structures for both the Parking and the Living trees resulted from the idiosyncratic thought processes of the individuals who created them. Other individuals might have produced different trees. If our trees are to be useful in assessing the completeness of act generation performance, some indication of their generality should be available. Manning (note 6) has provided one such check on the generality of the tree used to assess the Parking problem. In an investigation of the subjective dimensions used by subjects in thinking about acts for the Parking Problem, she performed a complete-linkage cluster analysis on acts having positive utility. The output of this analysis is a hierarchical tree, which is given as Appendix D. Her tree includes only acts generated by the subjects from the Parking problem judged to be of positive utility. Despite this difference, there are real similarities between the experimenter-generated tree in Appendix B and the tree resulting from cluster analysis in Appendix D. Her major limbs 1., "Do more with University-owned space" and 2., "Expand parking to surrounding areas" are similar to the limb 2., "Increase available space for parking" in Appendix B. Similarly, her limb 3., "Use alternate forms of transportation" is similar to branch 3.3 in Appendix B, "Introduce or encourage alternate forms of transportation". There are differences between the two trees, but the differences are not great enough, in our opinion, to render the experimenter-generated trees unusable for making judgments about the completeness of human act generation.

Individual act generation performance. Individuals in the Parking and Living problems generated an average of 11.2 and 12.1 acts, respectively. The number of acts generated for the Parking and Living problems ranged from 2 to 35. Similar large individual differences in performance were observed by Manning, et. al. (1980) in hypothesis generation. Subjects generated an average of 3.3 limbs for the Parking problem and 4.2 limbs for the Living problem. Subjects generated an average of 1.92 branches for each limb they generated for the Parking problem, and 1.52 branches for each limb generated for the Living problem.

The number of acts generated in each limb or branch is shown to the left of each limb or branch in the trees given in Appendices B, C, and D. The frequency of acts in Appendix D is lower because only positive utility acts were included. Also included is the probability of generating at least one act in a limb or branch. For example, the notation "14" followed by "(.37)" for limb 1 of the Parking problem means that there were 14 acts in limb 1 and 11 of the 30 subjects (37%) generated at least one of the 14 acts.

Inspection of these frequencies for the Parking problem tree yields several conclusions. First, while limb 2, "Increase available space for parking", and limb 3, "Reduce demand for parking", were generated by almost all subjects (p=.97 in each case), other major limbs such as limb 1 and limb 4 were only generated by about a third of the subjects. Limb 1, "Use available parking space more efficiently", is an important limb the University is currently implementing. Parking lots are being redesigned to be more efficient using the 1.1, 1.2, 1.5, 1.6, and 1.7 branches shown on the tree. Similarly, rethinking parking priorities (limb 4) could noticeably improve the parking situation. However, two out of three subjects did not think of these (obvious in hindsight) limbs.

Secondly, while most subjects generated at least one act in limbs 2 and 3, many other major branches which one would expect a large proportion of the subjects to generate did not show large proportions. For example, providing incentives such as reserving parking places for people who carpool (3.4.2) would be an effective act which would cost the University almost nothing, yet this act was only rarely suggested by subjects.

A similar analysis can be made using the tree constructed from cluster analysis for the Parking problem. Only 30% of the subjects thought of branch 1.2, "Reorganize current parking areas", yet this is the most cost-effective way to increase the available parking given the strong shift to subcompact cars in the university community. Only 37% of the subjects thought of branch 3.3, "Promote other forms of transportation". Bicycle riding would probably become much more popular if a way could be found to reduce bicycle thefts and bicycle paths were built to separate bicyclists from pedestrians and motorists.

In the Living problem, 90% of the subjects generated at least one act in limb 1.0, "Live with someone without paying rent", and in limb 3.0, "Obtain money from other sources". Eighty percent of the subjects generated at least one act in limb 2.0, "Exchange goods or services for money or a place to live". However, only 27% of the subjects thought to ask someone else for housing suggestions (limb 4) and only 60% considered having the friend modify his plans (limb 6). While most subjects generated at least one act in limb 1, "Live with someone without paying rent", the majority only considered having the friend live with someone he knows rather than explore other sources. In limb 2, "Exchange goods or services for money or a place to live", 63% of the subjects thought of selling goods or services to make money, but less than half considered exchanging his services for living quarters. In limb 3, "Obtain money from other sources", only a third of the subjects suggested applying for financial assistance.

Obviously there is a subjective element in these analyses. Readers will have to inspect the trees and reach their own conclusions. We were surprised by the deficiencies in subjects' performance even though our earlier research on hypothesis generation suggested subjects would fail to think of important acts.

The source of these failures is an interesting topic for speculation. The problems were picked so we could argue that most important acts would be "available" in memory, but not neccessarily "accessible" (Tulving and Pearlstone, 1966). In other words, we believe that the requisite information is available in the memories of most of our subjects due to their experiences with personal transportation, or their experiences with finding accommodations for themselves or their friends. Therefore, we are inclined to attribute most of the difficulty in act retrieval to failure to access information available in memory. Perhaps an expert would have less difficulty accessing material used on a daily basis. On the other hand, we believe that important decisions are not necessarily made by experts who make similar decisions on a daily basis. Often "generalists" such as politicians, military officers, and lawyers are found in decision making roles. Do they have difficulties in accessing information similar to our subjects' difficulties? We suspect so.

We do not believe many of the failures to generate important limbs and branches are due to a hyper-critical attitude on the part of our subjects towards the acts they retrieved from memory. As can be seen from an inspection of the trees, many responses are counter-productive or useless, suggesting the subjects were trying to follow instructions by responding with everything that came to mind. Why would they make frivolous responses rather than suggest acts which might have been effective?

We cannot preclude a motivational explanation for some failures to think of important limbs and branches. We went to considerable pains to design instructions and procedures for our experiments to motivate the subjects. Most subjects spent about an hour in the experiment, which was restricted to a single problem. Many subjects found the experiment intrinsically interesting and treated it as a contest or a game. Nevertheless, some retrieval failures probably were due to insufficient motivation.

Our conclusion from inspecting these data is that the tree produced by the individual subject often lacks important limbs and branches. We presented almost all the data used in reaching this conclusion so the readers can reach their own conclusions. If our conclusion is accepted, the next logical step is to assess the cost of failing to generate a complete tree.

Experiment 2

The second major question of opportunity loss can be addressed by finding the utility of all unique acts in the "pooled-acts" tree. Once the utilities of various branches, limbs, and twigs are known, the tree produced by each subject can be compared to the pooled-acts tree, and opportunity loss can be calculated. If subjects do not generate a complete tree, but generate all important limbs and branches, opportunity loss will be negligible. If, however, important limbs and branches are omitted, opportunity loss will be large.

Figuratively, the first experiment examined how well subjects can sketch the pooled acts tree, and the remaining experiments examined whether the branches they sketch out are "heavy with fruit". An examination of the completeness of the structure is incomplete without an assessment of the consequences of failing to generate branches and limbs. Whereas the previous analysis relied heavily on such words as "important" or "useful" and invited the reader to agree or disagree with this judgment, an opportunity loss calculation injects an element of objectivity into the analysis.

Our primary difficulty in performing an opportunity loss calculation was that the "pooled-act" trees were much larger than we anticipated. We had planned to use a version of Multi-Attribute Utility scaling to estimate the utility of each act, but the large number of unique acts made this impossible. Instead, we were forced to settle for first, screening the unique acts to identify feasible acts of positive utility, and second, evaluating the utility of the screened acts by using a global utility estimation technique.

Consequently, we performed experiment 2 to provide a preliminary screening of the acts. The technique used was to ask subjects to identify acts having positive utility. Experiment 3 provided global utility estimates for acts judged to be of positive utility by most of the subjects in the preliminary screening.

Method

Subjects. Subjects were 60 introductory psychology students from the University of Oklahoma who participated in the experiment for course credit. Thirty subjects saw the Parking problem and 30 subjects saw the Living problem.

Procedure. The experiment was computer-controlled. Subjects first read the practice problem seen by subjects in the act generation experiment. The practice problem dealt with acts to be taken if the subject ran out of gas and had no money. Subjects were shown 4 sample acts and were asked to respond "yes" or "no" to the question of whether taking each specified act would leave them better off. A response to the question was made by typing either "Y" or "N" on the keyboard. After each response, subjects were given an opportunity to look at the problem again or to move on to the next act.

Following the practice problem, subjects read either the Parking or the Living problem. Subjects were told their task was to decide whether taking the specified acts would leave the involved parties better off than they currently were. Subjects were also encouraged to weigh the costs of taking any act against its potential benefits when deciding whether the act good. Subjects again evaluated acts by typing either "Y" or "N" on the keyboard. Subjects who saw the Parking problem evaluated 128 acts and subjects who saw the Living problem evaluated 155 acts.

Results and Discussion. The number of subjects who thought an act was of positive utility was determined. If the majority of subjects in the preliminary screening experiment rated an act as having positive utility, it was retained for use in the utility experiment. Fifty-seven acts were classified as being of positive utility in the Parking problem, and 67 in the Living problem.

The procedure used for preliminary screening was somewhat crude, but it should be remembered that opportunity loss is calculated by finding the difference between the best act on the "pooled acts" tree and the best act on a subject's tree. Consequently, the utility of acts having negative utility need not be known, as the influence of negative utility acts on the opportunity loss calculation is negligible (except in pathological cases).

Experiment 3

Techniques for assessing act generation performance

Many of the acts in the Parking and Living problems are not mutually-exclusive. Thus, it should be possible to create a "portfolio" (Cozzolino, 1974) of acts to address the problem. For example, parking at the University of Oklahoma could be improved by redesigning existing parking lots, building new lots, improving mass transit, etc. On the other hand, the Canadian student can only live in one place at a time, although other acts, such as getting more money, could be combined with acts suggesting where he might live. Therefore, a subject's performance should be evaluated in terms of both the best act generated and the number of high utility acts generated, because many acts could be taken simultaneously.

Portfolio analysis is a formal technique to identify the best mixture of acts to be taken. Unfortunately, the problems we are considering are not suitable candidates for such an analysis because some acts are mutually exclusive. Instead, we developed an analysis which embodies some of the ideas of portfolio analysis and addresses other dimensions of performance as well.

Suppose a subject produces an act tree consisting of limbs, branches, and twigs. Each act twig has an associated utility value obtained from a utility scaling procedure. Also imagine a comparable tree created by pooling the acts of the entire group of 30 subjects. The "group" tree will have many more branches and twigs, but if subjects perform well their "individual" trees should resemble a pruned "group" tree containing only the best limbs, branches and twigs.

A tree can be pruned at various levels. Twigs can be pruned from a branch until only the highest-utility twig remains. After twigs are thus pruned from each branch, branches retaining the best twigs can be pruned from a limb until only the highest-utility branch remains. Finally, limbs retaining only their best branch and twig can be pruned until only the highest-utility limb remains.

If both the "group" and "individual" trees were pruned to their single best limb, branch and twig, the act having maximum utility for each tree would be identified. The difference between the maximum utility act for the "group" tree and an "individual" tree would be the "opportunity loss" resulting from the subject's failure to generate the best possible act.

If, however, for both trees pruning stops after each branch is pruned so only the best twig (in a maximum utility sense) remains, then a pruned tree would consist of limbs and branches containing only the best twig available for that limb and branch. If the analysis is extended to these additional limbs and branches, an idea of the variety and completeness of the subject's tree structure can be obtained. A comparision between the best limb and branch of the two can still be made to calculate opportunity loss. The additional limbs and branches can be examined to assess the completeness of the "individual" tree. We have named this analysis "limbs and branches".

Once the tree has been pruned to this extent, it is a simple matter to prune it further, so each limb retains only its maximum utility branch and twig. The analysis performed on this type of tree is named "limbs only". The "limbs and branches" analysis and the "limbs only" analysis provide somewnat complementary information. If a "limbs and branches" analysis is performed, a comparision of the group tree with the individual tree is essentially an examination of how well a subject generates limbs and branches. If, on the other hand, a "limbs only analysis is performed, the emphasis is on how well a subject generates various limbs.

Suppose that the various versions of the group and individual trees outlined above are created. One way to summarize subjects' for limbs only performance is to create a cumulative utility function which sums the utilities of the limbs in order of decreasing utility. This is done by first taking the highest utility limb, adding this utility to the second-highest utility limb, etc. A similar analysis may be performed on the trees consisting of limbs and branches. The cumulative utility function resulting from this process increases monotonically, and eventually is aysmptotic. If the cumulative utility functions are calculated and plotted for the appropriate versions of the group and individual trees, a summary measure is created which captures both a subject's ability to generate the "best" act, and the ability to generate a variety of other good acts. The difference between the first points on two of these functions is "opportunity loss", and the differences between their remaining points can be used to assess the "completeness" of performance.

Method

Utility estimation technique. The utility estimation technique employed was direct utility estimation. Subjects were given two "anchor" acts, one identified as having a value of 0, the other a value of 100. They then made global utility estimates for all other acts by comparing each act with the two anchor acts. If subjects believed an act had a higher utility than the act identified as having a utility of 100, they were free to assign it a larger number. If they believed an act had a lower utility than the 0 utility anchor, they could assign it a negative number. The acts which served as anchors were selected using the results of experiment 2. For the Parking problem, the act "Improve the trolley and Campus Area Rapid Transit System..." was used as the upper anchor and was assigned a value of 100 because more subjects (29 out of 30) classified the act as being of positive utility than any other act in experiment 2. A utility of zero was assigned to the act of doing nothing about the Parking problem. The Living problem differed from the Parking problem in that the act "do nothing" was not viable, as the student needed a place to live. Consequently, we picked an act for a lower anchor which few subjects (3 out of 30) in experiment 2 felt was of positive utility. This act was "... hide in the library and sleep there at night...". While some students resort to similar tactics, this is obviously a poor solution to the problem. The act chosen to be the upper anchor involved appealing to relatives for help and was picked because all subjects thought it was of positive utility.

The two utility scales defined for the Parking and the Living Problems are not commensurate, because they have different-valued intervals. Consequently, comparisions between the Parking and Living problems cannot be made directly, because the scales are technically interval scales and are only unique up to a linear transformation. This issue will be discussed in more detail later.

Subjects. Twenty subjects were used for each problem. They were recuited from the same population as previous subjects.

Instructions. The instructions to the subjects were similar to those used in experiment 2. Subjects were told to rate acts generated by other subjects by making numerical utility estimates. They were instructed that their global estimates should incorporate the costs of implementing a particular act and possible outcomes resulting from that act.

Procedure. The procedure for the practice problem was the same as in experiment 2, except subjects made direct utility estimates. The computer screen displayed three acts. The two anchor acts were always present at the top and bottom of the screen, and were labeled 0 and 100. The act to be judged was displayed in the middle of the screen between the two anchors. Subjects entered a utility value into the computer terminal which represented their evaluation of the utility of the act to be rated as compared with the two anchor acts. The computer then advanced to the next act to be rated.

When the subjects finished the practice problem, they read the text of either the Parking problem or the Living problem. They made direct utility estimates for 57 acts from the Parking problem, or 67 acts from the Living problem. To insure subjects would be conscientious, they were required to justify the magnitude of their response for six randomly chosen acts. The subjects did not know for which acts they would be required to justify utility estimates until after they entered the estimate.

Results and discussion

The subjects' utility estimates were examined by plotting histograms of the distribution of the estimates for each problem. Almost all histograms were unimodal, but there was considerable variation among the subjects' estimates. The median utility estimate was used as a measure of central tendency to reduce the influence of outlying scores.

The "limbs only" and "limbs and branches" analyses. A computer program performed the "limbs only" and the "limbs and branches" analyses described above. It also performed a similar analysis on unpruned trees, but the results of this analysis were so similar to those of the "limbs and branches" analysis that they will not be reported. The input to the program was the classification of acts created by the experimenters and the median utility estimates obtained from experiment 3. The output of the program was a cumulative utility function for the group tree consisting of pooled acts generated by all subjects. This function shows the cumulative utility for the total number of limbs for the "limbs only" analysis, and the ten highest utility limbs and branches for the "limbs and branches" analysis. In each case the first point in the function is the maximum utility act, the second point is the second-ranked act, etc. Table 1 shows the data used in the group "limbs and branches" analysis for the Parking problem. The frequencies of generating acts illustrate individual performance and were not a part of the group analysis.

Table 1

The best 10 limbs and branches from the "group" Parking problem tree

Utility	Number of subjects generating act	Action
100	2	Improve the trolley and CART systems.
77.5	19	Build a high-rise parking lot.
60	2	Put more small car parking spaces in student lots.
60	1	Have employees park at Lloyd Noble, use trolley.
57.5	1	Build lots around Norman, shuttle in students.
55	3	Reduce the price of parking stickers for carpools.
55	2	Advertise advantages of riding bike, motorcycle.
51	3	Have more selection of afternoon, evening courses.
50	1	Use some OU service vehicle parking for students.
50	3	Use extra areas around fraternities for overflow.
616 sum of utilities	30 possible for each act	

The acts shown in table 1 are the 10 best acts from the group tree for the Parking problem. The cumulative utility function was obtained from the column of utilities shown in the table. Also shown is the number of subjects generating each act. The individual analyses were similar to this, with one important exception. The ten best acts for an individual were not necessarily those shown in table 1, but were the ten best acts generated by the individual. An inspection of the number of subjects generating the acts used in the group analysis shows the typical subject's ten best acts included some acts from the group analysis, but also included many lower-utility acts not shown in table 1. Therefore, the individual analyses were similar in principle to the group analysis, but were based on individual performance.

The results of the "limbs and branches" and the "limbs only" analyses are shown in figures 1 through 4 for the Parking and Living problems. Each figure shows the "group" cumulative utility function, the "mean" function obtained by averaging the cumulative utility functions for each subject, and the "best" function obtained from the best subject in the analysis. The difference beween the first point of the "group" function and the first point of either of the other functions is the opportunity loss due to failure to generate the highest utility act.

Opportunity loss results. The opportunity loss due to failure to generate the best act was 29 utiles (100-71) for the Parking problem and 18.15 utiles for the Living problem (100-81.85). One way of thinking about the meaning of the opportunity loss figures is to imagine the utility distance between the average subject's performance and the upper and lower anchors used in experiment 2. The utility of the best act for the average subject in the Parking problem was 71. This utility value is 71 percent of the distance from the lower anchor, and 29 percent of the distance to the upper anchor. The utility of the best act for the average subject in the Living problem was 81.85. This utility value is 81.85 percent of the distance from the lower anchor and 18.15 percent of the distance to the upper anchor. It should be recalled that these opportunity loss figures are lower-bound estimates. The actual opportunity loss values may be somewhat higher.

One cannot conclude, however, that the performance of subjects in the Living problem was superior to the performance of subjects in the Parking

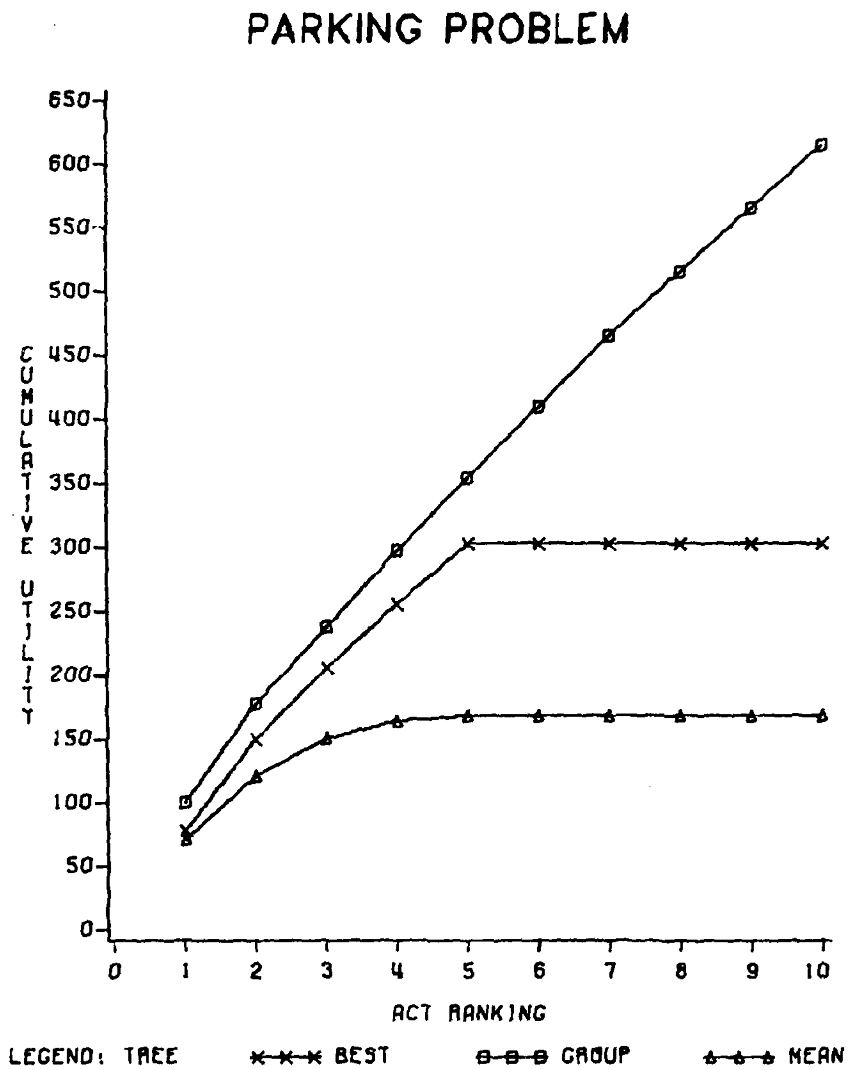

FIGURE 1. CUMULATIVE UTILITY FUNCTIONS FOR "LIMBS AND BRANCHES" ANALYSIS

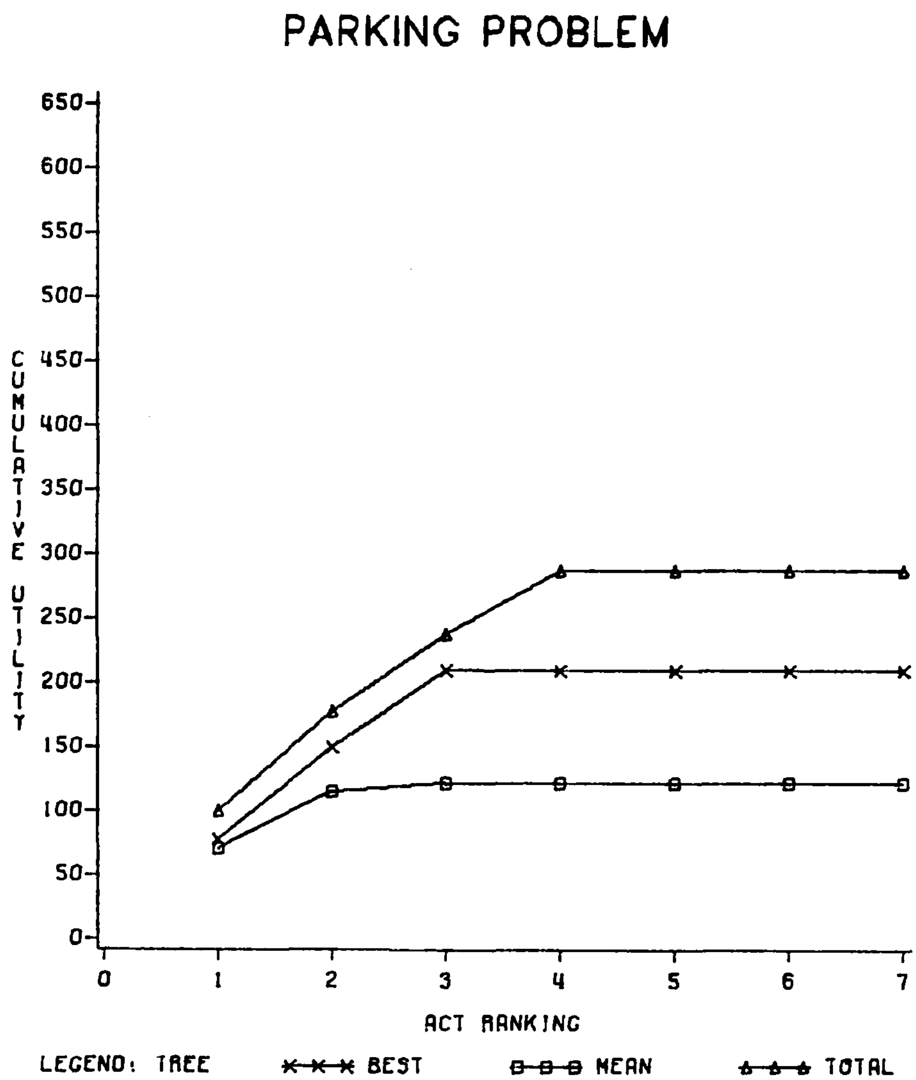

FIGURE 2. CUMULATIVE UTILITY FUNCTIONS FOR "LIMBS ONLY" ANALYSIS

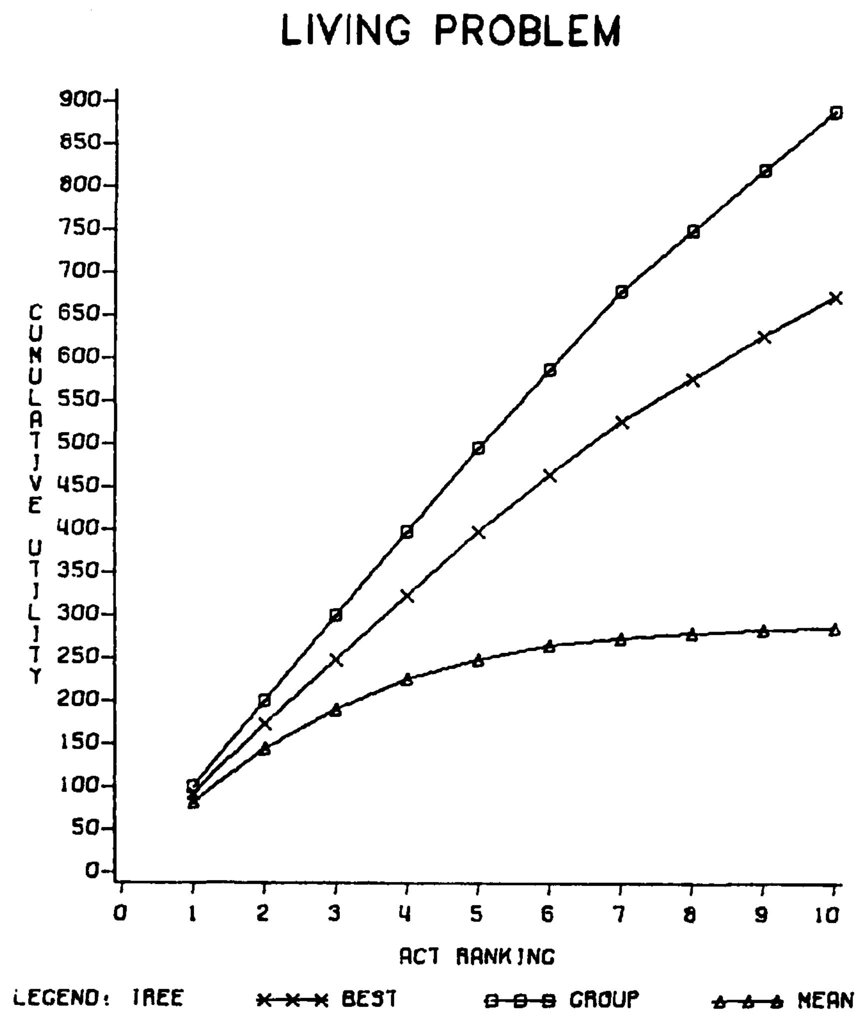

FIGURE 3. CUMULATIVE UTILITY FUNCTIONS FOR "LIMBS AND BRANCHES" ANALYSIS

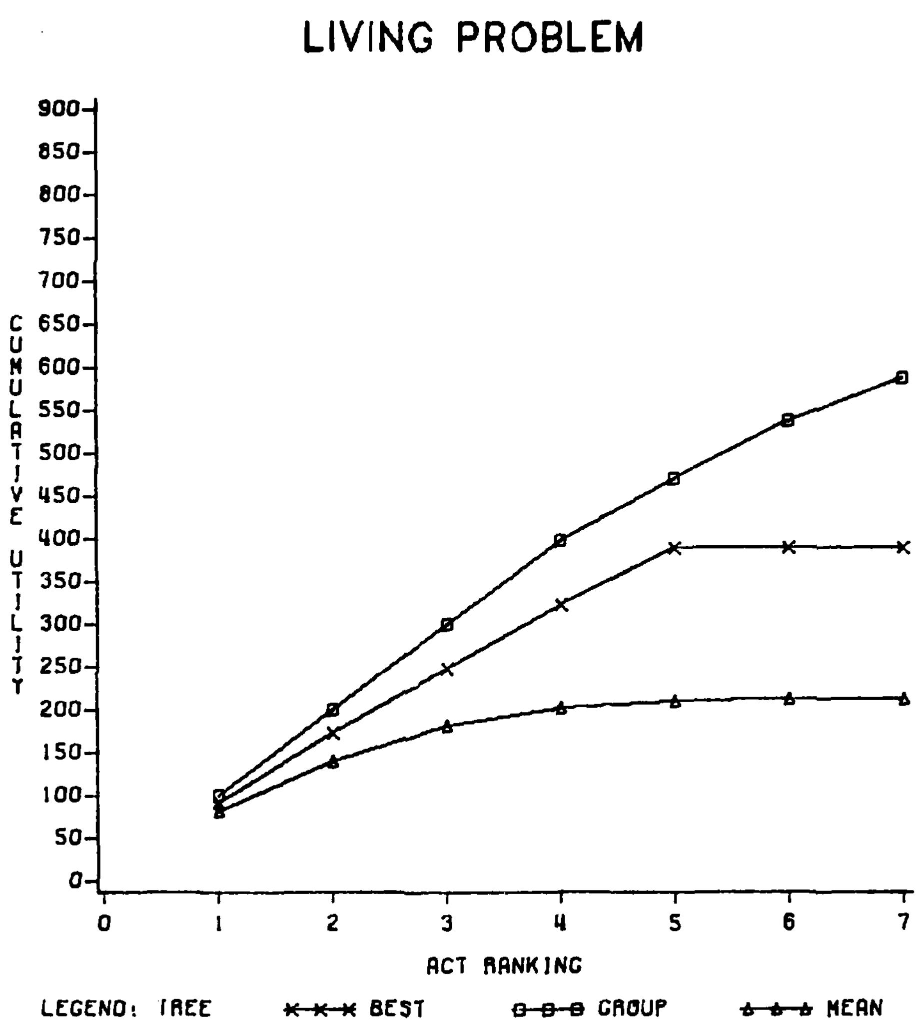

FIGURE 4. CUMULATIVE UTILITY FUNCTIONS FOR "LIMBS ONLY" ANALYSIS

problem because the two utility scales are not commensurate. Utility scales are unique up to a linear transformation. No data are available to translate the utility units of the Parking scale into the units of the Living scale. Our impression is that the opportunity loss values are roughly comparable for the two problems. It will be recalled that the act serving as the lower anchor in the Parking problem was to do nothing, whereas in the Living problem it was to sleep in the Library. Therefore, the anchors in the Living problem may encompass a greater range of utility than the anchors for the Parking Problem, suggesting each utility point in the Living problem scale has greater value than each point in the Parking problem scale. Therefore, the opportunity loss of 29 utiles for the Parking problem may represent about the same loss as the 18.15 utile loss for the Living problem.

Did subjects generate many high-valued limbs? The question of the completeness of each subject's tree is pertinent to the topic of decision problem structuring. Decision analysis employs many powerful and sophisticated techniques to decide if an act should be included in a decision analysis. Obviously, if a decision maker fails to generate the act, the benefits of subsequent decision analysis are lost. Decision analysis depends on the quality of the decision maker's work when generating elements of the structure. This issue can be addressed by examining the remainder of the cumulative utility functions shown in figures 1 through 4. The difference in utility between the first and last points on each cumulative utility function is related to the completeness of the associated tree.

Table 2 displays the differences between the "group" and "mean" cumulative utility functions. For example, in the "limbs and branches" analysis for the Parking problem, the difference between the first and last points of the "mean" cumulative utility function was 97.6 (168.6-71). The difference between the first and last points of the "group" cumulative utility function was 516 (616-100). Another column shows the ratios (expressed as percents) of the utility differences for the "group" function to the utility differences for the "mean" function for each problem.

Table 2

Utility Differences from the Cumulative Utility functions

	Parking Problem			Living Problem		
	"Mean"	"Group"	Percent	"Mean"	"Group"	Percent
"limbs and branches analysis"	97.6	516	528%	201.9	750	371%
"limbs only analysis"	52.2	187	358%	129	463.5	359%

Table 2 reveals an interesting result. Subjects are unable to generate a complete assortment of high utility acts such as those a Decision Analyst might hope to elicit from a client. Subjects do not generate many high utility limbs and branches. When the analysis is confined to limbs, a similar picture emerges. In fact, after inspecting the data from which the opportunity loss calculations were derived, we have developed a rather unflattering picture of human act generation capabilities.

First, many acts occurring to subjects are of zero or negative utility. Subjects in the Parking problem generated an average of 11.2 acts. Of these 11.2 acts, 4.4 or 39%, on the average, were judged to be of positive utility. Only a few of the 4.4 positive utility acts generated by the average subject were of high utility. The results from the Living problem were similar. The average subject generated 12.1 acts. Of these 12.1 acts, 6.5, or 54%, on the average were of positive utility. Subjects in the Living problem tended to generate more high-utility acts, and tended to generate acts of higher utility. Table 3 summarizes the data on which these conclusions were based. It gives the mean number of acts in each utility class interval for the two problems for indivdual subjects. Also given are the number of acts from the group tree in each utility class interval.

Table 3 presents the relationship between utility of acts and the frequency with which the acts were generated by individual subjects. A "perfect" act generator should perform at least as well as the group tree, but we do not expect our subjects to approach perfection. The cumulative utility functions address subject performance in a more realistic way. Table 3 shows, however, subjects generate only a few viable acts, far fewer than would be desirable from the point of view of decision analysis.

Table 3

The Utility Distribution of Acts Generated by Subjects Compared to the Group Tree

Utility values (Midpoints of interval)	Parking Problem individual	Parking Problem group	Living Problem individual	Living Problem group
0*	6.67**	75	5.56	72
10	.30	5	.03	1
20	.20	6	.20	4
30	.43	11	.70	8
40	.90	6	1.10	13
50	.67	12	1.47	10
60	.70	6	.56	10
70	.47	4	.86	9
80	.67	1	.93	4
90	.0	0	.50	3
100	.07	2	.13	5

* This class interval contains acts eliminated in experiment 2. Many of these acts would have had negative utility estimates had they been included in experiment 3.

** These entries are the mean number of acts having utilities within the specified range.

A check on the generality of these results via cluster analysis. The "limbs" and "limbs and branches" analyses described above were repeated for the tree constructed for the Parking problem using cluster analysis. Graphs of the cumulative utility functions for these analyses are shown in Appendices E and F. Similar conclusions were reached from the analyses. The opportunity loss calculation was unchanged in this analysis, as it is not affected by the structure of the tree used in the analysis. Utility differences were calculated using the tree derived from the cluster analysis and are reported with the corresponding results from table 2 in parentheses following each result. For the "limbs and branches" analysis, the "group" function had a utility difference of 539 (516) utiles. The "mean" individual function showed a utility difference of 119.5 (97.6) utiles. A ratio of 451% (528%) was found between the group and mean individual performance. In the "limbs only" analysis, the group value showed a 210 (187) utile difference and the corresponding "mean" individual function showed a difference of 87.5 (52.2) utiles. The ratio between group and "mean" individual performance was 240% (358%).

While changing the structure of the tree seems to slightly affect the results, the same general conclusions can be made with regard to the assessment of the completeness of subjects' act generation performance. Subjects do not generate many high utility acts. In fact, their ability to generate possible acts in a decision situation can be fairly characterized as "impoverished".

Conclusions

Pooling, trees, and utility estimation: an advance in methodology.

The methodology used in these experiments represents an advance over earlier techniques used to study act generation. Lorge, Fox, Davitz and Brenner (1958) surveyed a number of studies contrasting individual and group performance, some of which were concerned with act generation. These studies typically evaluated performance by counting the number of responses subjects made. The more recent study of Pitz, et. al. (1980) used a similar technique.

The pooling technique, the construction of hierarchical act trees, and the estimation of utility of acts all represent, we believe, advances in methodology which allow the researcher to address issues of quality as well as quantity. While these methods have problems, such as the effort required to implement them, they may prove useful in other contexts. For example, the efficacy of various structuring techniques used in decision analysis could be examined. These methods should also prove generally useful for the study of predecision processes. The availability of a hierarchical act tree constructed by pooling subjects' acts should facilitate the study of the cognitive processes, such as memory search strategies, involved in predecision processes. They should also facilitate the study of rules a decision maker uses to determine whether a potential act should be considered further.

Generalizing these results to other contexts

Problem solving tasks. The problems employed in this study are representative of an important class of problems in which the goal is fairly well defined, but the steps needed to reach the goal are not specified (Taylor, 1974). Most problem-solving research has been confined to problems in which the goal and the steps taken to reach the goal are well defined. For example, in chess (de Groot, 1965), potential acts involve a limited set of moves, and the problem confronting the player is to arrive at the best sequence of acts. Problems in which the possible acts are unspecified are more common, and usually are more important. We suspect the lack of attention to problems in which possible acts are not specified is due to their apparent intractability. Our research suggests that the intractability is more apparent than real. In any event, the results reported here would seem to be relevant to problem solving, and should not be considered relevant to decision theory issues alone.

Expertise revisited. Earlier a distinction was drawn between an expert who performs a task on a daily basis and has possible acts readily accessible in memory, and the "generalist" who may not be able to easily access acts in memory. In our past research on hypothesis generation (Mehle, note 5; Gettys, et. al., note 4), experts and nonexperts attempted to generate possible reasons why an automobile malfunctioned. The results from both populations were similar, suggesting experts and nonexperts have similar deficiencies in hypotheses generation due to the operation of certain cognitive mechanisms. It was not claimed that expertise was of no value; many tasks cannot be performed unless the requisite information is in memory. It is too early to know whether similar conclusions can be drawn for act generation. However, the magnitude of the results reported here suggests the variable of expertise should be investigated in act generation.

Human act generation performance assessed.

In summary, these experiments address two major questions, one dealing with the completeness of act generation performance, and the other dealing with the cost of failure to generate important acts. Subjects appeared to be impoverished act generators, suffering both in the _quantity_ and the _quality_ of acts generated.

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FOOTNOTES

We wish to thank Nancy Shelton, who participated in the initial planning of this project. We also wish to thank Paul Foster, who ran countless numbers of subjects.

A special thanks goes to the late Dick Rubrecht, our shop technician, who cheerfully hunted for and repaired our hardware problems. He will be long remembered.

Appendix A

A PLACE TO LIVE

Imagine that your friend is a new OU student from Canada. He was able to earn and borrow enough to move to Norman and pay his tuition and fees but he does not have enough money to rent an apartment or live in the dorms. In fact, his monthly check from his parents will barely pay for his meals. Somehow he has to make arrangments for a place to live for the rest of the semester.

The US Immigration Service prohibits foreign students from working, so suggesting that your friend get a job to earn money to rent an apartment would not solve the problem. Also, your friend has exhausted his credit at Financial Aids, and cannot get loans from any other source. Your friend will not do anything illegal that might result in his being deported.

Your task is to suggest as many possible solutions for his problem as you can. These solutions need not be perfect or ideal, in fact solutions that have definite drawbacks are entirely acceptable as long as they have the possiblility of solving his problem for the rest of the semester. Your solutions to this problem should not be minor variations of the same solution.

It is important that you enter all new options which occur to you. This is similar to 'thinking out loud.' We do not want you to censor your options and only enter the ones which you think are particularly good. Put down all options which occur to you, good or bad. Your score in this experiment is determined by the number of options you generate not by how good they are.

APPENDIX B

ACT STRUCTURE FOR PARKING PROBLEM

Based on all "logically distinct" acts, PARKING experiment

14 * (.37) ** 1. Use available parking space more efficiently

2 (.07) 1.1 Put "small car" spaces in student parking lots

3 (.07) 1.2 Reduce "non-parking" space in lots

1.2.1 do away with "no parking" zones
1.2.2 do away with extra curb space in lots

1 (.03) 1.3 Slant parking spaces (diagonal parking)

2 (.07) 1.4 Require users to buy small cars

2 (.07) 1.5 Segregate cars according to size

3 (.10) 1.6 Pack the cars in more tightly by painting the lines closer together

1 (.03) 1.7 Remove 30 minute parking meters

86 (.97) 2. Increase available space for parking

40 (.70) 2.1 Convert more University land into parking

2.1.1 At the dorm
2.1.2 On the South Oval
2.1.3 At the Duck Pond
2.1.4 On the grass
2.1.5 Convert University Streets to parking
2.1.6 At Lloyd Noble (basketball) Stadium
2.1.7 By tearing down old buildings
2.1.8 By parking on top of buildings
2.1.9 By parking inside the football stadium

19 (.47) 2.2 Buy or use non-University land to create more parking

2.2.1 Buy adjacent houses, convert to lots
2.2.2 Use adjacent shopping center at night
2.2.3 Reserve streets around University for University parking
2.2.4 Use areas around fraternities as University Parking
2.2.5 Use church parking lots

26 (.67) 2.3 Build parking structures

2.3.1 underground stuctures
2.3.2 high-rise parking structures

1 (.03) 2.4 All future buildings should be high-rise so that more land around them will be available for parking

156 (.97) 3. Reduce demand for parking

6 (.13) 3.1 Restrict number of cars allowed to park

3.1.1 by lottery: those who lose ride motorcyles
3.1.2 allow only one car for every three students

25 (.53) 3.2 Outlaw cars

3.2.1 make everybody ride bikes
3.2.2 make everybody ride bikes or motorcycles
3.2.3 for faculty and staff except at Lloyd Noble
3.2.4 except for cars used in carpooling
3.2.5 make commuter students park at Lloyd Noble and use the trolley to Main Campus
3.2.6 for employees: require them to take cabs
3.2.7 except for commuters
3.2.8 of students who live in Norman
3.2.9 of Fraternity members from Campus and have them park at their Frats

59 (.83) 3.3 Introduce or encourage alternative forms of transportation

3.3.1 wide-spread rapid-transit
3.3.2 busing for surrounding area
3.3.3 encourage mopeds, bicycles, and motorcycles
3.3.4 people who live within one mile are asked to walk or ride bikes
3.3.5 reduce bicyle thefts to increase bike riding
3.3.6 build bicycle paths to increase bike riding
3.3.7 sell low-priced bicycles
3.3.8 carpooling for students, staff or faculty
3.3.9 provide transportation from South Campus
3.3.10 improve the Trolley and CART Systems
3.3.11 get a real trolley car on a track
3.3.12 store dorm residents' cars off-campus with bus to their cars
3.3.13 bus service to shopping, entertainment, etc. would reduce need for cars
3.3.14 promote the use of roller-skates
3.3.15 build sidewalks and improve security on Campus

11 (.23) 3.4 Raises or incentives for employees or students who

3.4.1 don't drive to school
3.4.2 carpool
3.4.3 run to work
3.4.3 ride motorcycles

3 (.07) 3.5 Make it fashionable not to drive to work

3.5.1 Form "Volksmarch" clubs to encourage walking
3.5.2 Form cycling clubs

5 (.17) 3.6 Educate people about commuting alternatives

3.6.1 advertise advantages of bikes and motorcycles
3.6.2 educate students in conserving gasoline
3.6.3 to improve enviornmental quality

9 (.30) 3.7 Encourage students not to bring their cars to Campus from home

3.7.1 unless they really need them
3.7.2 when they are Freshmen
3.7.3 if they live on campus

2 (.07) 3.8 Build moving sidewalks

14 (.27) 3.9 Reduce peak demand for parking

3.9.1 Schedule classes differently to reduce demand
3.9.2 Have employees work alternate days
3.9.3 Have empoyees drive only on alternate days
3.9.4 Let commuters plan their schedules first so that they can carpool
3.9.5 Make commuters stagger class schedules

10 (.27) 3.10 Increase the fees for parking permits

4 (.13) 3.11 Build more on-campus housing for students

3 (.10) 3.12 Offer more correspondence courses so students will stay at home

3 (.10) 3.13 Impound cars of all violators of parking regulations

1 (.03) 3.14 Raise parking fees to reduce demand

1 (.03) 3.15 Build Campus in direction of open, unused areas so more parking will be available in the future

12 (.33) 4. Change parking priorities

3 (.10) 4.1 Do away with restricted parking (decaled)

2 (.07) 4.2 Let people park anywhere they want to

2 (.07) 4.3 Allot a specific place for each student

4.3.1 based on seniority

1 (.03) 4.4 Reduce service vehicle parking

2 (.07) 4.5 Reduce faculty parking to increase student parking

1 (.03) 4.6 Do not allow GAs to park in faculty parking

1 (.03) 4.7 Make times when Faculty-Staff parking is open more flexible B2

5 (.07) 5. Provide faculty and staff with housing within walking distance

1 (.03) 5.1 on top of the place where they work

61 (.60) 6. Frivolous and other responses

1 (.03) 6.1 Move the University to the students by establishing branch campuses

1 (.03)	6.2 Encourage more enrollment of foreign students (because not as many own cars)
6 (.20)	6.3 Reduce student population 6.3.1 make OU an "all girls" school
4 (.13)	6.4 Have a helicopter pick everybody up for work
1 (.03)	6.5 Increase the enrollment cost
2 (.07)	6.6 I would have someone towed away to create a space for me
1 (.03)	6.7 Counterfeit Faculty parking stickers
7 (.13)	6.8 Destroy "useful" areas 6.8.1 tear down Owen Field (Football Stadium) 6.8.2 destroy OU 6.8.3 destroy Frat Houses
3 (.07)	6.9 Do away with current University programs to create parking 6.9.1 Football 6.9.2 Oklahoma College of Continuing Education
7 (.13)	6.10 Build subway
3 (.03)	6.11 Destroy cars 6.11.01 threaten to destroy cars
1 (.03)	6.12 Fire teachers
1 (.03)	6.13 Take away parking from other branches of the University 6.13.1 Post Office Training Program
2 (.07)	6.14 Rambling, incoherent thoughts
1 (.03)	6.15 Let only people who have paid for cars drive
3 (.10)	6.16 Don't let people who attend drive 6.16.1 allow only walkers to attend University 6.16.2 make everybody live on campus
1 (.03)	6.17 Have your parents drive you to school
1 (.03)	6.18 Make everybody walk who has less than a 2.3 GPA
4 (.03)	6.19 Impossible acts 6.19.1 issue everybody a pair of wings 6.19.2 issue strength pills 6.19.3 beam them to school (in a matter transporter) 6.19.4 use reducing or shrinking cars

1 (.03) 6.20 Discourage use of cars by

6.20.1 saying that the Surgeon General has found cars cancerous

1 (.03) 6.21 Send minorities to Central State University

2 (.03) 6.22 Iranian (some of these data were collected when the American hostages were returned from Iran)

6.22.1 Nuke Iran
6.22.2 Take Iranians hostage until they give OU money for parking lots

1 (.03) 6.23 Let only ladies drive

1 (.03) 6.24 Have everybody drive golf carts

1 (.03) 6.25 Ban all foreign cars

1 7 (.03) 6.26 Have computerized lot that destroys all cars exceeding limits

1 (.03) 6.27 Use area we have now for parking instead of building the new facilities that are planned

1 (.03) 6.28 Have harder working employees so you don't need so many

1 (.03) 6.29 Only hire people in wheel chairs

1 (.03) 6.30 Only hire people who like to run

1 (.03) 7.0 Responses that combine two or more options from above

* The number of acts in each limb or branch.

** The proportion of subjects who gave limb or branch.

(tree with act numbers on June 81 qrt. report disk. This tree on July 81 TR disk.)

APPENDIX C

Act Structure for Living Problem

93 (.90) 1. Live somewhere without paying rent

37 (.77) 1.1 With person he knows

1.1.1 With me
1.1.2 With friends
1.1.3 With my parents
1.1.4 Have his parents move here
1.1.5 With relatives in Norman

23 (.40) 1.2 With person(s) he doesn't know

1.2.1 In fraternity house
1.2.2 With person of opposite sex
1.2.3 Someone with extra room in apartment
1.2.4 Relatives' friends
1.2.5 With experimenter
1.2.6 With religious cult
1.2.7 With sponsor

4 (.13) 1.3 Public institution

1.3.1 Salvation army
1.3.2 Police station

26 (.47) 1.4 Miscellaneous places

1.4.1 Tent
1.4.2 Streets
1.4.3 Outside
1.4.4 Misc. school buildings
1.4.5 Car
1.4.6 Trash dumpster
1.4.7 Empty house
1.4.8 Motel laundry room
1.4.9 Extra dorm room

3 (.10) 1.5 Pay for room only, get board free

76 (.80) 2. Exchange goods or services for money or place to live

19 (.47) 2.1 He could exchange services for place to live

2.1.1 With me
2.1.2 With someone in town
2.1.3 Could be Resident Assistant

57 (.63) 2.2 He could exchange goods or services for money

2.2.1 Sell plasma
2.2.2 Write book or articles
2.2.3 Sell paintings or photographs
2.2.4 Sell candy
2.2.5 Sell possessions
2.2.6 Clip coupons to sell
2.2.7 Have carnival
2.2.8 Sing or juggle in street
2.2.9 Collect beer cans
2.2.10 Form punk rock band

2.2.11 Give benefit concert for self
2.2.12 Enroll in work-study

104 (.90) 3. Obtain money through other sources

33 (.70) 3.1 Try to get loan

3.1.1 From friends
3.1.2 From bank
3.1.3 From loan shark
3.1.4 Through me
3.1.5 From me
3.1.6 From relatives
3.1.7 From private sponsors
3.1.8 From government

19 (.33) 3.2 Apply for financial assistance

3.2.1 For housing
3.2.2 Apply for scholarship
3.2.3 From government
3.2.4 From school
3.2.5 Enroll as foreign exchange student

33 (.70) 3.3 Ask for money

3.3.1 From other relatives
3.3.2 From my parents
3.3.3 From his parents
3.3.4 Beg on street
3.3.5 Put ad in paper to ask for contributions

19 (.27) 3.4 Donations

3.4.1 Monetary donations from me
3.4.2 Of living quarters
3.4.3 Fund-raising projects
3.4.4 Take up collection

16 (.27) 4. Ask someone for suggestions or help

9 (.17) 4.1 Someone you know

4.1.1 Professor
4.1.2 Friend
4.1.3 Relatives
4.1.4 My parents
4.1.5 Boyfriend's mother

3 (.07) 4.2 School officials

1 (.03) 4.3 Roommate agency

3 (.07) 4.4 Community organization

5 (.17) 5. Try to get regulations changed

5 (.17) 5.1 on working

30 (.60) 6. Change current plans

2 (.07) 6.1 Wait to go to school till gets more money

5 (.17) 6.2 Take fewer hours

3 (.10) 6.3 Go to less expensive school

1 (.03) 6.4 Commute from Canada

1 (.03) 6.5 Eat less, cheaper food

1 (.03) 6.6 Work in Mexico for semester

3 (.03) 6.7 Break law so will be deported

14 (.43) 6.8 Go home

5 (.13) 7. Prepare in advance

1 (.03) 7.1 Apply for citizenship 149

2 (.07) 7.2 Invest money 134,135

1 (.03) 7.3 Establish residency before coming 146

1 (.03) 7.4 Pay bills so have good credit rating 148

29 (.40) 8. Long shots

5 (.13) 8.1 Look for money

8.1.1 Gold 49
8.1.2 In street 53
8.1.3 With metal detector 127

9 (.10) 8.2 Steal money

8.2.1 Rob bank 36

9 (.20) 8.3 Get money through questionable, illegal methods 37

8.3.1 Assassinate relatives 98
8.3.2 Have old person put him in will 97
8.3.3 Sell sister to white slaver 132
8.3.4 Get hit by car, sue driver 128
8.3.5 Jump off Dale Hall to attract attention 129
8.3.6 Get a job anyway 123
8.3.7 Form own non-profit corp 155

4 (.10)	8.4 Get money through luck
	8.4.1 Save child from drowning, get reward 131 8.4.2 Win sweepstakes 34
1 (.03)	8.5 Pray for solution to problem 144
1 (.03)	8.6 Incur revolution 147
4 (.10)	9. Acts which will not solve problem
1 (.03)	9.1 Commit suicide 150
2 (.07)	9.2 I could kill him 152,154
1 (.03)	9.3 I would plead guilty to his illegal activities 153

APPENDIX D

Tree derived from complete linkage cluster analysis for Parking Problem

31 (.80) 1.0 Do more with university-owned space.

20 (.63) 1.1 Structures designed to aid parking problem

1.1.1 Build high rise.
1.1.2 Build new buildings as high rises.

11 (.30) 1.2 Reorganize current parking areas

1.2.1 Repaint lines, decrease width of spaces.
Repaint lines, have cars park in certain areas.
1.2.2 Put more small car parking in student section.
1.2.3 Make enough spaces for everyone living in dorms.
1.2.4 Raise parking fees to improve, expand lots.
Improve condition of facilities.
1.2.5 Remove 30 minute meters.

32 (.53) 2. Expand parking to surrounding areas

5 (.13) 2.1 Create more parking space in surrounding areas

2.1.1 Put parking signs up on streets around campus.
2.1.2 Build lots in different locations, shuttle in.
2.1.3 Look for available area instead of building new facilities.

12 (.37) 2.2 Build more lots

2.2.1 Expand Lloyd Noble parking facility.
Expand present areas.
2.2.2 Build more lots.
2.2.3 Build another lot like Lloyd Noble.
Build more places like Lloyd Noble.
2.2.4 Build a new lot by the jock dorms.

4 (.10) 2.3 Change parking status in certain areas

2.3.1 Make some faculty parking student parking.
2.3.2 Regulate staff parking hours more closely.
2.3.3 Use OU vehicle parking for students.

11 (.20) 2.4 Use other areas for parking

2.4.1 Don't have so many no parking zones.
2.4.2 Let people park on the South Oval.
2.4.3 Request parking at Stubbeman Village.
2.4.4 Use areas around frats for overflow parking.
2.4.5 Use church lots.
2.4.6 Make frat members park at their own houses.

36 (.60) 3. Use alternate forms of transportation

13 (.43) 3.1 Carpooling

3.1.1 Encourage carpooling by commuters.
3.1.2 OU could organize a carpool.
3.1.3 Provide greater incentives for carpooling.
Reduce price stickers for carpools.
3.1.4 Ask commuters to carpool.
Use carpools.

6 (.20) 3.2 Encourage people not to drive.

3.2.1 Encourage people not to bring cars.
3.2.2 Counsel students about parking problem.
Make more knowledge about commuting available.
3.2.3 Have more selection of evening courses available.

17 (.37) 3.3 Promote other forms of transportation.

3.3.1 Advertise the advantages of riding a bike or motorcycle.
More students could ride bikes.
3.3.2 Form cycling clubs for commuters.
3.3.3 Encourage students to stop pollution by riding bikes.
Ask all students to ride bikes.
3.3.4 Build bike paths.
3.3.5 Provide more security for bikes.

34 (.77) 4.0 Park elsewhere, get other transportation in.

6 (.13) 4.1 Force members of university community to park elsewhere.

4.1.1 Mandatory parking for faculty, staff at Lloyd Noble.
4.1.2 Have employees park at Lloyd Noble, use trolley.
4.1.3 Have commuters park at Lloyd Noble, use trolley.
4.1.4 Make all commuter parking at Lloyd Noble.

28 (.73) 4.2 Encourage parking in other areas by making rapid transit available.

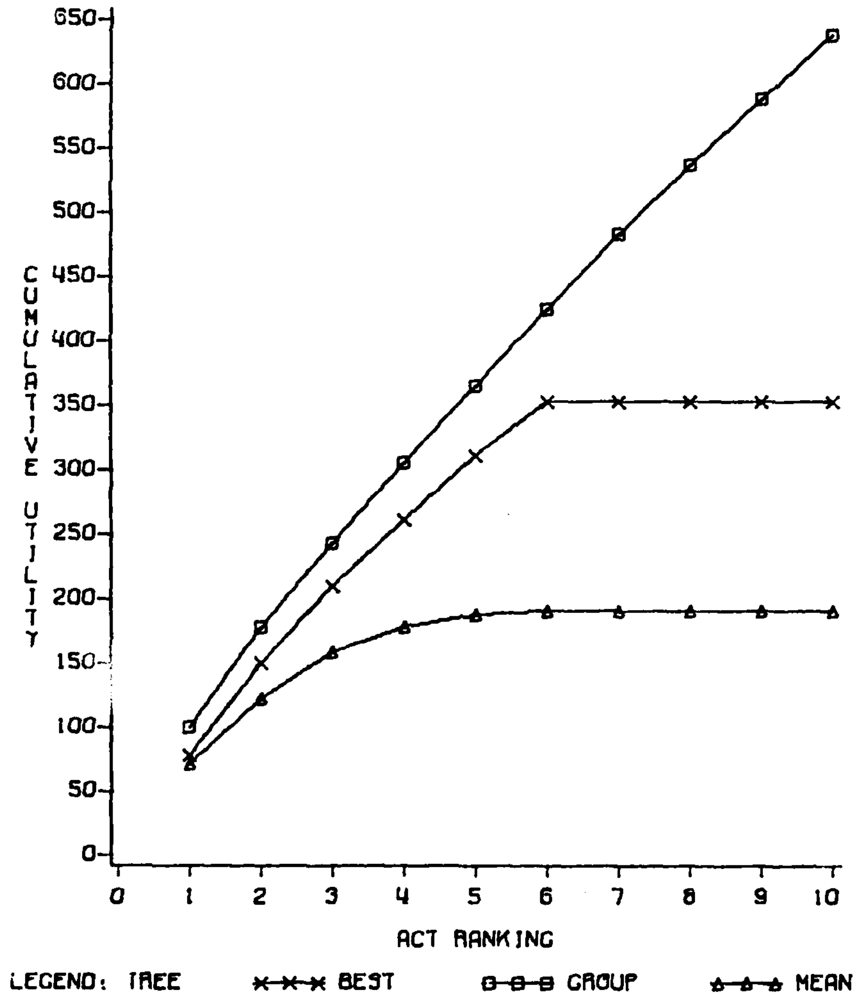
4.2.1 Set up rapid transit system during school hours.
Set up bus system for surrounding area.
Set up bus system for surrounding communities.
Set up mass transit system for Norman.
4.2.2 Enact bus system from campus to shopping malls.
4.2.3 Improve trolley and CART systems.
Provide more trolleys and busses.
Provide transportation from South campus.

3 (.10) 5. Impound cars without stickers.

197 (.97) 6. All acts having zero or lower utility which were not a part of the cluster analysis

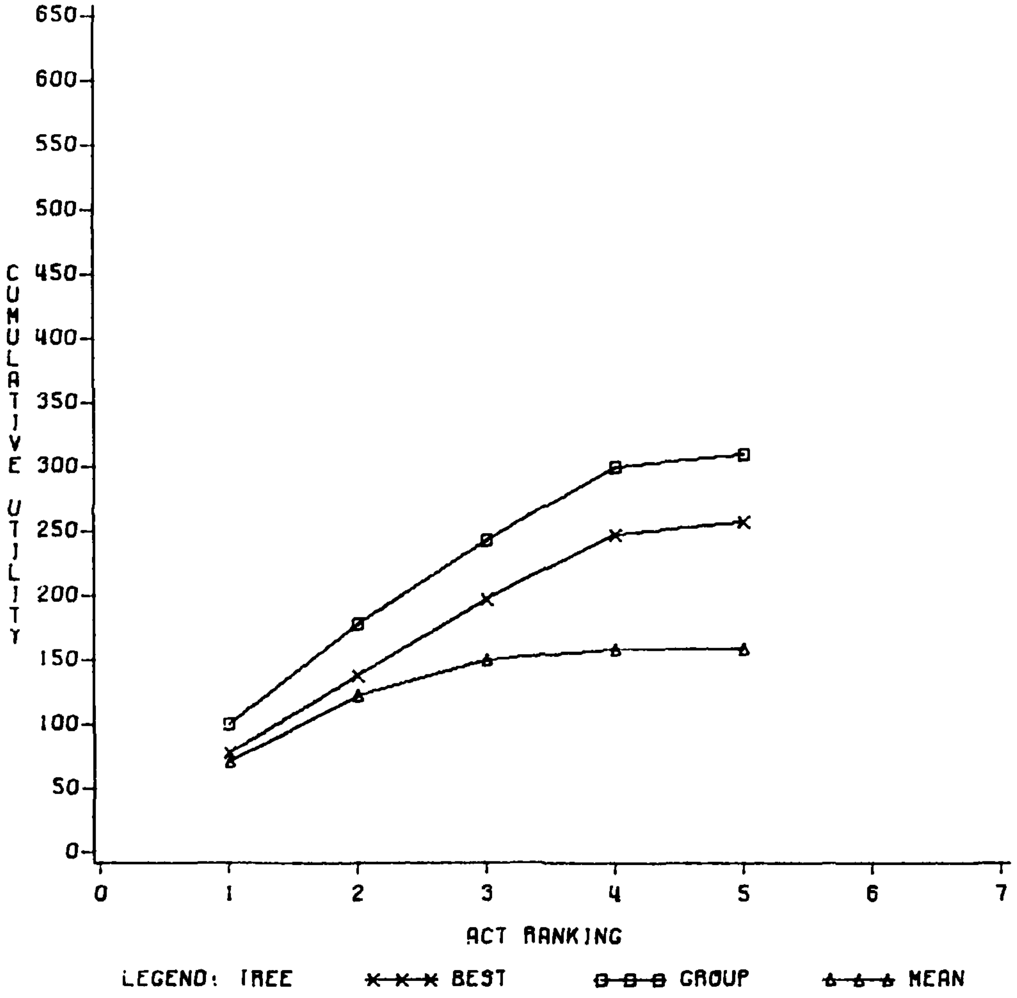
(On disk 146)

APPENDIX E
PARKING PROBLEM
TREE DERIVED FROM CLUSTER ANALYSIS



CUMULATIVE UTILITY FUNCTIONS FOR "LIMBS AND BRANCHES" ANALYSIS

APPENDIX F
PARKING PROBLEM
TREE DERIVED FROM CLUSTER ANALYSIS



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Code 100M
Office of Naval Research
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Arlington, VA 22217

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Washington, D.C. 20380

HQS, U.S. Marine Corps
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Alexandria, VA 22333

Director, Organizations and
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U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Technical Director
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Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Technology Establishment
Teddington, Middlesex TW11 OLN
ENGLAND

Director, Huamn Factors Wing
Defence & Civil Institute of Environmental Medicine
Post Office Box 2000
Downsview, Ontario M3M 3B9
CANADA

Foreign Addresses

Dr. A. D. Baddeley
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Medical Research Council
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Cambridge, CB2 2EF
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Defense Advanced Research Projects Agency
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Arlington, VA 22209

Dr. Judith Daly
Cybernetics Technology Office
Defense Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

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Defense Intelligence School
Washington, D.C. 20374

Other Organizations

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Human Factors Research, Inc.
5775 Dawson Ave
Glleta, CA 93017

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Institute of Behavioral Sciences
University of Colorado
Boulder, CO 80309

Dr. Miley Merkhofer
Stanford Research Institute
Decision Analysis Group
Menlo Park, CA 94025

Dr. Jesse Orlanksy
Institute for Defense Analysis
400 Army-Navy Drive
Arlington, VA 22202

Professor Judea Pearl
Engineering Systems Department
University of California-Los Angeles
405 Hilgard Avenue
Los Angeles, CA 90024

Professor Howard Raffia
Graduate School of Business Administration
Harvard University
Soldiers Field Road
Boston, MA 02163

Dr. Arthur Siegal
Applied Psychological Services, Inc.
404 East Lancaster Street
Wayne, PA 19087

Dr. Paul Slovic
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Amos Tversky
Department of Psychology
Stanford University
Stanford, CA 94305

Other Organiz ations

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NAS-National Research Council
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Washington, D.C. 20418

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University of Southern California
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1820 Dolly Madison Blvd
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Dr. Douglas Towne
University of Southern California
Behavioral Technology Laboratory
3716 S. Hope Street
Los Angleles, CA 90007

Dr. John Payne
Duke University
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Durham, NC 27706

Dr. Baruch Fischoff
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Andrew P. Sage
University of Virginia
School of Engineering and Applied Science
Charlottesville, VA 22901

Dr. Leonard Adelman
Decisions and Designs, Inc.
8400 Westpark Drive, Suite 600
P.O.Box 907
McLean, VA 22101

Dr. Lola Lopes
Department of Psychology
University of Wisconsin
Madison, WI 53706

Other Organizations

Dr. Rex Brown
Decision Science Consortium
Suite 721
7700 Leesburg Pike
Falls Church, VA 22043

Mr. Wayne Zachary
Analytics, Inc.
2500 Maryland Road
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Mr. Joseph G. Wohl
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Act generation
Decision theory
Decision structuring

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A series of experiments addressed the adequacy of act generation performance, an important precursor to problem structuring. Each of two decision problems was studied by a series of three experiments. In the first experiment, subjects were given a realistic decision problem and asked to respond with

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20. (continued)

any act occurring to them. In the second experiment, the acts suggested were evaluated by different subjects for feasibility. In a third experiment, additional subjects estimated the utility of the acts judged feasible. The act generation performance of subjects was evaluated using two techniques. First, a decision tree was generated by the experimenters by combining the acts suggested by all subjects. The decision tree generated by each subject was compared with the experimenter-generated tree. It was found that subjects failed to generate important limbs and branches of the group decision tree. Second, the quality of the trees generated by individual subjects was evaluated by an opportunity loss calculation. This calculation provides an estimate of the potential cost of failing to generate limbs and branches of the decision tree. The opportunity loss analysis suggested that the failure to generate a complete tree could be costly.

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